The Effects of Black Army Cutworm on Backlog Reforestation Efforts in the North Thompson Valley

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March 1988

ECONOMIC & REGIONAL DEVELOPMENT AGREEMENT

Canada

BC

Funding for this research project and the cost of printing this publication were provided by the Canada/British Columbia Forest Resource Development Agreement - a five year (1985-90) $300 million program cost-shared equally by the federal and provincial governments.

Canadian Cataloguing in Publication Data

Maher, Thomas Francis, 1954-
The effects of black army cutworm on backlog reforestation efforts in the North Thompson Valley

(FRDA report, ISSN 0835-0752 ; 022)

Co-published by B.C. Ministry of Forests and Lands.
On cover: Canada/B.C. Economic & Regional Development Agreement.
Issued under Forest Resource Development Agreement.
Bibliography: p.
ISBN 0-7718-8623-3

1. Black cutworm. 2. Conifers - Diseases and pests - British Columbia - North Thompson River Valley. 3. Reforestation - British Columbia - North Thompson River Valley. I. Canadian Forestry Service. II. British Columbia. Ministry of Forests and Lands. III. Canada/BC Economic & Regional Development Agreement. IV. Forest Resource Development Agreement (Canada) V. Title. VI. Series.

SB945.C92M33 1988 634.9'75 C88-092046-7

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This is a joint publication of the Canadian Forestry Service and the British Columbia Ministry of Forests and Lands.

Produced and distributed by the Ministry of Forests and Lands, Research Branch.

For additional copies and/or further information about the Canada-British Columbia Forest Resource Development Agreement, contact:

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EXECUTIVE SUMMARY

The black army cutworm, *Actebia fennica* (Tauscher), is a major pest of newly established conifer plantations in British Columbia. A problem analysis was undertaken to assess its impact on backlog reforestation in the North Thompson Valley.

This insect has a one year life cycle, emerging as an adult moth in summer, and depositing eggs 2 to 5 weeks later, usually on slashburned sites. Larvae are inactive over winter and feed in spring on the foliage of herbaceous plants and conifer seedlings for 5 to 6 weeks before pupation. Seedling damage can include complete or partial defoliation, destruction of buds and bark feeding which may result in height and growth reduction, deformity, reduced competitive ability, or mortality. Depending on the damage type and severity (both influenced by several site, temporal and insect population factors), infested sites may require replanting, interplanting or no treatment at all.

Analysis of 26 recorded black army cutworm infestations in the study area revealed four locations where seedlings were damaged. The only attributes common to these locations were biogeoclimatic zone and the interval between burning date and planting date. All damage locations occurred in the Interior Cedar Hemlock Zone, and were planted in the second season after burning. Current stocking levels were also surveyed. Because of natural regeneration, only one of the four damaged plantations fell below the minimum stocking standard. The investigation concludes that the actual and potential impacts of this pest to date in the North Thompson Valley are low. However, the cost of even a small number of failures is high. To minimize any future losses, the following recommendations are given:

1. Pheromone trapping programs should be established at all broadcast burned sites to monitor black army cutworm populations. If burning takes place well after moth flight, seedlings may be safely planted the following spring. If moth flight and oviposition take place after burning, planting should be delayed until after spring larval feeding, if populations develop.
2. Planting crews should be instructed in black army cutworm identification and asked to report any evidence of larval feeding.
3. Infested plantations should be mapped and surveyed for damage and mortality levels (preferably one year after the infestation) and these documents kept on file.
4. Planting of infested areas should be delayed only until after larval feeding is complete to avoid severe vegetation competition. Lodgepole pine, which is more tolerant of defoliation than spruce, should be used in high-risk areas.
5. The effects of burning intensity on the selection by black army cutworm moths of burned sites for oviposition, and the differences in the damage and mortality levels sustained by different types of planting stock should be investigated.

ACKNOWLEDGMENTS

The author would like to acknowledge the assistance and co-operation of the following personnel whose involvement was essential to the completion of this project: Dr. A. Van Sickle, Dr. Lee Humble, and Mr. Leo Unger of the Canadian Forestry Service; and Mr. Bob Hodgkinson, Mr. Tim McCarthy, Mr. Scott Lindeburg, Mr. Mark Faliszewski, Mr. Bernie Ivanco, and Ms. Catherine Bealle of the B.C. Forest Service.

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1 INTRODUCTION

The black army cutworm, *Actebia fennica* (Tauscher), has recently become a forest pest in newly established coniferous plantations throughout the central Interior of British Columbia. Before 1964, infestations of the black army cutworm (BAC) in the province were recorded solely in agricultural situations (Allen and Wood 1973). Since then, BAC populations have been identified in forest plantations in all locales, with the exception of the Vancouver Forest Region. Coniferous hosts of the BAC include the spruces, (*Picea* species), lodgepole pine (*Pinus contorta* Dougl.), and Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco.) (Ross and Illnytzky 1977). Infestations of the BAC in plantations generally occur where broadcast burning has been the site preparation technique. Burned-over areas seem to be preferred locations for egg deposition by the adult moths (Phipps 1927; Ross and Illnytzky 1977).

Reforestation efforts have been steadily increasing throughout the province during the past several years. Since the signing of the Forest Resource Development Agreement between the federal and provincial governments, additional emphasis has been placed on the planting of backlog areas (harvested more than 3 years ago), which at present are "not satisfactorily restocked" (NSR).

Because of the large amount of NSR land, the consistent association of BAC infestations with recent broadcast burning, and the high proportion of broadcast burned sites with a recorded history of BAC populations, a problem analysis was undertaken to study the effects of the BAC on backlog reforestation efforts in the North Thompson Valley. The results of this problem analysis are presented in this report.

2 OBJECTIVES AND METHODS

The overall objective of this problem analysis was to provide forest managers with information on the past effects and future damage potential of the BAC in the North Thompson Valley. This objective was divided into three major components:

1. assessment of current stocking levels in North Thompson plantations which have incurred BAC seedling damage;
2. documentation of the history of BAC in the study area and description of the parameters associated with affected plantations; and
3. analysis of the potential of the BAC to hamper backlog reforestation in the future, with suggestions for appropriate management strategies.

To meet these objectives, several methods were used. First, a thorough review of the scientific literature dealing with the BAC was conducted, and the BAC history records of both the Canadian Forestry Service and the B.C. Forest Service were examined. All data pertinent to the BAC in the study area were collated. Second, four plantations damaged by the BAC were resurveyed. Survey lines were marked at the point of commencement by 1.2-m (4-ft) cedar stakes (painted and ribboned in blue) with identifying aluminum tags. All plot centres were similarly marked. Data were taken from 3.99-m radius plots and recorded on Survival Staked Plot (FS 707) forms. Third, all personnel actively engaged in BAC research within the province were interviewed.

3 RESULTS

3.1 Biology and Damage

The life cycle of the BAC was described by Wood and Neilson (1956). This member of the Noctuidae family is a univoltine species, taking 1 year to complete its cycle. The actual calendar dates of each life stage can vary significantly from year to year, depending on weather conditions, geographical location, aspect, and elevation. The BAC's life cycle in British Columbia can be summarized into eight stages (Wood and Neilson 1956; Ross and Illnytzky 1977; Blackstock 1985):

- Emergence and flight of adult moths (Figure 1) occurs from early July to the middle of September.
- Oviposition in the soil takes place from 2 to 5 weeks after emergence.
- Eclosion (under laboratory conditions) occurs at least 2 months after egg laying.
- The overwintering stage is presumed to be newly-hatched larvae but no observations of this stage have been made in British Columbia.
- Active feeding by the larvae (Figure 2) begins as soon as the snow cover has melted, usually during the month of May. Larval feeding takes place during darkness, but daylight feeding occurs when night temperatures are too low to stimulate larval activity. Herbaceous plants are the preferred hosts.
- The larvae pass through six instars in the 5 to 6 weeks before pupation.
- The pupal stage lasts for about 3 to 4 weeks.
- Following pupation, the adult moths emerge to complete the life cycle.

Unfortunately, detailed biological information such as life table studies and population dynamics are not available. However, recent work by Hodgkinson (1986) and Blackstock (1985) has indicated trends in the species of herbaceous vegetation that the BAC prefers to defoliate during an infestation. Obviously, the most commonly defoliated plants differ with site, but succulent plants such as Indian hellebore (*Veratum viridae*), false Solomon's seal (*Smilacina racemosa*), and Hooker's fairybells (*Disporum hookeri*) appear to be highly preferred by BAC larvae.

When BAC populations infest coniferous plantations, the results can range from no seedling damage to total destruction of the plantation. Depending on the level of seedling damage, the subsequent impact on reforestation may take one of three forms:

1. Complete re-planting may be required.
2. Inter-planting to achieve minimum stocking standards may be required.
3. There may be no effect.

During an infestation, seedling damage can include complete defoliation (Figure 3), partial defoliation (Figure 4), destruction of buds, and bark feeding. These may, in turn, cause height and growth reduction, seedling deformity, reduced competitive ability and/or mortality. There are several elements that influence the type and level of seedling damage:

- quantity and quality of herbaceous vegetation
- species of seedling
- timing of defoliation in relation to planting date
- weather
- stock type
- population level

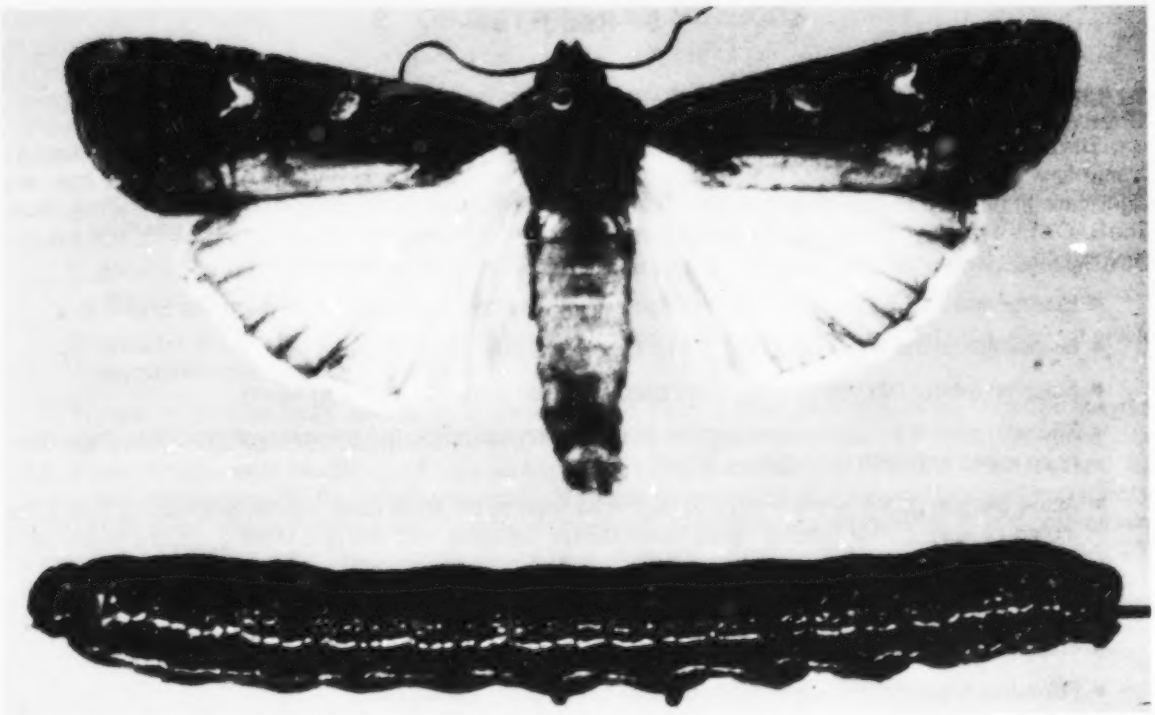

FIGURE 1. Adult moth and larva of the black army cutworm, *Actebia fennica*.

FIGURE 2. Larva of the black army cutworm, *Actebia fennica*.

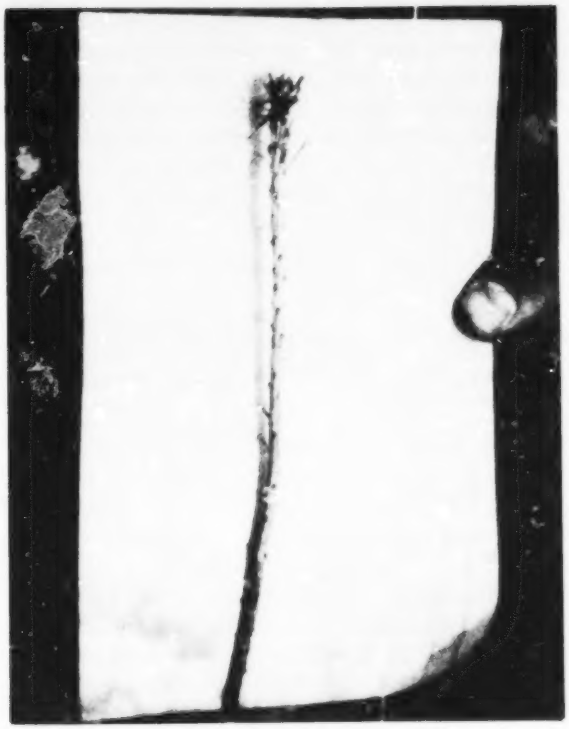

FIGURE 3. Complete seedling defoliation caused by black army cutworm larval feeding. The seedling has flushed and grown since defoliation.

FIGURE 4. Partial seedling defoliation caused by black army cutworm larval feeding. The seedling has grown for two seasons since the defoliation occurred.

Based on recent studies, the first three factors probably have the largest influence on the nature and degree of seedling damage. Zero to low levels of seedling defoliation will occur when sufficient herbaceous vegetation is available. Data from the Prince Rupert Forest Region indicates that mortality after complete defoliation varies significantly, depending on seedling species and date of establishment (Table 1). It appears that lodgepole pine is more tolerant of defoliation and incurs lower levels of mortality, than does white spruce. Mortality levels (regardless of species) are much greater when defoliation is concurrent with planting, than when defoliation occurs one year after planting. Thus, the relationship between burning date and planting date is crucial in terms of the impact of seedling defoliation on survival. This topic is discussed further in Section 4.

TABLE 1. Comparison of seedling mortality levels in relation to time of planting[a]

Host species	Mean percentage seedling mortality (range)[b]	
	Planted 0.5 years after burning	Planted 1.5 years after burning
Lodgepole pine	1.5 (0-5)	14 (10-25)
White spruce	10.0 (0-15)	45 (25-90)

[a] Data courtesy of Mr. Leo Unger, Canadian Forestry Service (pers. comm.).
[b] As compared to unaffected controls, all seedlings were completely defoliated 1.5 years after burning.

When the defoliation is not enough to cause mortality, its impact on reforestation depends on the level of seedling deformity, the amount of height growth loss, and the ability of the seedlings to compete successfully for site resources. Hodgkinson (1986) has shown that defoliated seedlings were 9 and 18% smaller in height (compared to controls) when the defoliation occurred 1 year after and concurrent with date of planting, respectively (Table 2). Leader growth reduction and damage the year following defoliation were also lower when the seedlings had been established for 1 year before defoliation. These data support the concept that loss associated with BAC defoliation varies considerably with the degree of seedling establishment (Ross and Illnytzky 1977).

TABLE 2. Comparison of height growth reductions and leader damage in relation to time of planting[a]

Characteristic (%)	Time of planting	
	One year before infestation (Cutting Permit 134-7)	During infestation (Cutting Permit 135-2)
Seedling defoliation	74	92
Bud damage	27	56
Difference in seedling height[b]	9	18
Difference in leader growth[b]	29	38
Missing leader	12.6	17.9
Dead leader	7.8	15.2
Multiple leader	13.0	17.5

[a] From Hodgkinson (1986).
[b] As compared to undefoliated controls.

3.2 The North Thompson Valley Situation

The Clearwater Forest District encompasses the North Thompson Valley and associated drainages, and it was therefore used as the study area for this project.

Of the seven forest districts within the Kamloops Forest Region, the Clearwater Forest District has the largest area of NSR land, consisting of more than 40 000 ha located primarily on good and medium sites (Table 3). Of this area, over 26 000 ha is considered to be backlog, representing over 20% of the backlog area in the Kamloops Forest Region.

TABLE 3. Area (ha) of NSR land in the Clearwater Forest District[a]

Category	Good	Medium	Low	Poor	Totals	Kamloops Forest Region	% of regional total
Current	1976	9488	2266	0	13 730	78 105	17.6
Backlog	3608	17 618	8	5484	26 718	108 615	24.6
Totals	5584	27 106	2274	5484	40 448	186 770	21.7

[a] Summarized from crop establishment historical records; courtesy of Mr. Bernie Ivanco, B.C. Forest Service, Kamloops Forest Region.

During the last 5 years, almost 40% of the broadcast burning in the Kamloops Forest Region has occurred in the Clearwater Forest District (Table 4). Within the district itself, broadcast burning is the predominant site preparation technique, accounting for 69% of the total post-harvest treatments.

TABLE 4. Levels of broadcast burning as a site preparation technique (ha)[a]

	Kamloops Forest Region		Clearwater Forest District		
Year	Broadcast burning	Total site preparation	Broadcast burning	Total site preparation	% of district site preparation
1985	4474	10 963	1615 (36%)[b]	2130 (19%)[b]	75.8
1984	4769	10 586	1800 (38%)	1900 (18%)	94.7
1983	5649	11 876	1921 (34%)	3056 (26%)	62.8
1982	2151	8042	679 (31%)	2117 (26%)	32.1
1981	1837	6383	1498 (82%)	1673 (26%)	89.5
Total	18 880	47 850	7513 (39%)	10 876 (23%)	69.1

[a] Summarized from B.C. Forest Service Silviculture Program Annual Reports.
[b] District data calculated as a percentage of regional data.

Within the Clearwater Forest District, substantial increases in reforestation are planned. Projected estimates indicate that seedling allocations and planted areas for 1987 and 1988 will be almost double those of 1982-86 (Tables 5 and 6).

TABLE 5. Historical summary of planting levels (ha)[a]

	Kamloops Forest Region			Clearwater Forest District[b]		
Year	Basic	Backlog	Total	Basic	Backlog	Total
1982	7776	2268	10 044	1604 (21%)[b]	1202 (53%)[b]	2806 (28%)
1983	12 452	2621	15 073	2259 (18%)	667 (26%)	2936 (19%)
1984	13 150	2186	15 336	953 (7%)	962 (44%)	1915 (12%)
1985	10 116	3050	13 166	1234 (12%)	1035 (34%)	2269 (17%)
1986	12 467	3113	15 580	1836 (15%)	618 (20%)	2454 (16%)
1987[c]	18 080	4320	22 400	3020 (22%)	1280 (30%)	5200 (23%)
1988[c]	22 800	4320	26 400	5760 (25%)	1280 (30%)	7040 (27%)

[a] Summarized from B.C. Forest Service Silviculture Program Annual Reports.
[b] District percentages are based on regional totals.
[c] Projected estimates based on August 1986 nursery stock data; courtesy of Mr. Mark Faliszewski, B.C. Forest Service, Kamloops Forest Region.

TABLE 6. Historical summary of planting levels (thousands of trees)[a]

	Kamloops Forest Region			Clearwater Forest District[b]		
Year	Basic	Backlog	Total	Basic	Backlog	Total
1982	9347	2753	12 100	2016 (22%)	1521 (55%)	3537 (29%)
1983	15 156	3481	18 637	2969 (20%)	946 (27%)	3242 (17%)
1984	15 496	2338	17 834	1315 (8%)	1204 (51%)	2519 (14%)
1985	13 175	3270	16 445	1705 (13%)	926 (29%)	2613 (16%)
1986	16 165	3903	20 068	1377 (15%)	760 (19%)	3137 (16%)
1987[c]	22 600	5400	28 000	4900 (22%)	1600 (30%)	6500 (23%)
1988[c]	28 500	5400	33 900	7200 (25%)	1600 (30%)	8800 (26%)

[a] Summarized from B.C. Forest Service Silviculture Program Annual Reports.
[b] District percentages are based on regional total.
[c] Projected estimates.

The historical records of BAC in the CFD showed comparatively low levels of BAC activity. On examining both B.C. Forest Service and Canadian Forestry Service (Forest Insect and Disease Survey) data, a total of 26 BAC records were identified. Of these, eight records showed negative results from larval surveys and one record was an infestation in an alfalfa field. The remaining 16 records are summarized in Table 7.

TABLE 7. Historical summary of black army cutworm infestations in the North Thompson Valley[a]

Year	Location	Tenure	C.P.[b] No.	Population	Seedling Damage
1973[c]	Redsands	T.S.H.L.[d] A01029	9	Low	Light
1974	Moose Lake	N/A	N/A	Low	None: some feeding on fireweed
1974	Coldscaur Lake	N/A	N/A	Low	None: some feeding on fireweed
1974	Coldscaur Lake	N/A	N/A	Low	None
1974	Lempriere Creek	T.S.H.L.[d] A00815	1	N/A	N/A
1975	Thunder River	N/A	N/A	Low	None: 3 larvae on fireweed
1975	Lempriere Creek	T.S.H.L.	6	Low	None: some feeding on fireweed
1976	Gill Creek	N/A	N/A	Low	None: larval survey
1976	Wylie Creek	N/A	N/A	Low	None: larval survey
1976	Blue River	N/A	N/A	Low	None: larval survey
1982[c]	Adolph Creek	T.S.H.L.[d] A00815	40	High	High: 100%
1982	Adolph Creek	T.S.H.L.[d] A00815	49	Moderate	N/A: some adult moths trapped
1982[c]	Foam Creek	T.S.H.L.[d] A01029	72(A)	N/A	N/A
1984	East Mad River	F.L. A18694	42(E)	Low	N/A
1984	Bill Creek	Sedgewick	KLS	Low	N/A
1985[c]	Raft River	F.L.[e] A18688	37 (Blocks 2 & 9)	Moderate	Light

[a] Summarized from Canadian Forestry Service, Forest Insect and Disease Survey records and Clearwater Forest District files.
[b] Cutting Permit.
[c] Indicates locations resurveyed in 1986.
[d] Timber Sale Harvesting Licence.
[e] Forest Licence.

Closer scrutiny revealed that seedling damage was recorded in only four locations. These sites were selected for further study (see Appendix for map). Examination of history records and files indicated no common site characteristics among the four locations except biogeoclimatic zone (Table 8). An attempt was made to compare broadcast burning conditions for each block but was unsuccessful because the data were inconsistently formatted for differing record keeping systems. At each location, site visits and survival surveys were undertaken and plots established to determine current stocking levels.

TABLE 8. Descriptive summary of plantations damaged by the black army cutworm in the Clearwater Forest District[a]

Characteristic	Location			
	Raft River	Foam Creek	Adolph Creek	Redsands
Area affected (ha)	25	25	19	80
Old timber type	CS 941	SB 841	FS 851	BS 841
Site class	Poor	Medium	Good	Medium
BGC[b] zone	ICH	ICH	ICH	ICH
BGC subzone	m	m	w	m
BGC association	IV	I	IV	N/A
Aspect	NW	W	S	W
Elevation (m)	1066	1342	1100	1150
Soil texture	Sandy Loam	Gravel Loam	Sandy Loam	Sandy Loam

[a] Summarized from crop establishment historical records (FS 393), planting site prescriptions (FS 739), and planting reports (FS 753) forms.
[b] Abbreviation for "biogeoclimatic".

3.2.1. Redsands block

In late August 1971, approximately 170 ha were broadcast burned following many years of selective logging. Engelmann spruce (*Picea engelmanni*) seedlings were planted on 100 ha in May and June 1973 (Table 9). The stock was in very dry condition, and a large percentage had multiple leaders. An infestation of BAC was identified in a localized area on June 22, 1973, and, by July 12, it had spread to 80 ha and seedling defoliation had occurred. Several survival surveys were conducted between the completion of planting and August 1973. Results were extremely variable, ranging from 16 to 87% survival. The block was listed as NSR in August 1973, but a subsequent survey in June 1980 indicated a 50% survival rate of the planted stock (748 stems per hectare) and the stocking status was changed to "satisfactorily restocked". The 1986 survey showed a stocking level of 1460 stems per hectare, which is above the minimum stocking standard for the area.

The overall mortality rate of planted stock in this location, from all causes including BAC, was just under 50%, and natural ingress has resulted in acceptable stocking levels. Therefore, the impact of the BAC on reforestation in the Redsands block has been low, as the resulting natural fill-in offset the seedling mortality from all causes including the BAC.

TABLE 9. Historical summary of plantations damaged by the black army cutworm in the Clearwater Forest District[a]

Parameter	Location			
	Raft River	Foam Creek	Adolph Creek	Redsands
Date of burning	August 1983	August 1980	August 1980	August 1971
Date of planting	June 1985	June 1985	June 1982	June 1973
Species	Spruce	Spruce	Pine	Spruce
Stock type	PSB 211	PSB 211	PSB 211	Bare root
Planting density	1200	1400	1475	1500
Stocking level[b]	1200	450	642	748
1986 survey[c]	1036	1475	575	1460
Minimum stocking standard[d]	1050	1050	1000	1000

[a] Summarized from Planting Report (FS 753) and Survival Survey Summary (FS 716) forms.
[b] Taken from the most recent survey in each location; includes only planted trees.
[c] Includes both planted and natural trees.
[d] Minimum acceptable stocking levels for each biogeoclimatic subzone and association.

3.2.2 Adolph Creek block

This location was clearcut in 1979 and broadcast burned in August 1980. There are no records indicating BAC on the site in 1981. However, a wildfire occurred in an adjacent block (Map Reference 83DIId-7019) in July 1981, which may have brought BAC populations into the area. In June 1982, lodgepole pine (*Pinus contorta*) seedlings were planted on 19 ha in the western corner of the block (Table 9). The weather during planting was unusually hot and dry. On June 12, 1982, a large BAC population was reported to have caused 100% defoliation of the planted stock. In July 1984, a survival survey indicated only 641 trees per hectare (42% survival) and this block is currently classified as NSR. The 1986 survey confirmed this classification.

The seedling mortality rate for lodgepole pine in this location is greater than rates reported in Table 1, possibly because of the hot and dry weather conditions during and immediately after planting. However, the actual causes of mortality are unknown. The impact of the BAC infestation in this block is therefore unknown, but additional planting will be required to secure adequate stocking levels.

3.2.3 Foam Creek block

The circumstances surrounding the BAC infestation in this block are similar to those of the Adolph Creek block, with the exception of wildfire adjacent to the Adolph Creek block. The block was logged in 1979 and broadcast burned in August 1980. Planting of spruce (*Picea engelmanni*) seedlings was initiated in June 1982, but discontinued after 2 days when BAC larvae were observed. The seedlings were returned to Clearwater and returned to the site 2 weeks later. Planting was then completed.

In May 1983, replanting was recommended because of losses from the BAC. The unattacked portions of the block were planted with spruce and pine in June 1983. A survival survey of the BAC-affected portion of the plantation was undertaken in October 1984. It indicated a survival rate of only 32% of the planted stock (450 stems per hectare). However, 563 stems per hectare of natural ingress were also recorded, resulting in a total stocking level of 1013 stems per hectare — just under the minimum stocking standard. Further ingress of natural regeneration was recorded during the 1986 survey (Table 9), which showed a total stocking level of 1475 stems per hectare.

The overall mortality rate of 68% observed in this location is within the range reported for spruce in Table 1. However, the degree to which high temperatures and excessive movement and handling of the planted stock contributed to seedling mortality is unknown. Regardless of the cause, natural ingress has offset the initial reduction in stocking, and this location is currently considered to be satisfactorily restocked.

3.2.4. Raft River block

This is the most recent BAC infestation recorded in the Clearwater Forest District. Clearcut logging was completed in winter 1982 and the western portion (25 ha) of the block was burned in August 1983. A major escape from this burn destroyed a previously established plantation in the eastern portion (32 ha), and both areas were scheduled for planting. Spruce planting was undertaken in June 1985, but discontinued after 2 days because of BAC populations. As a result, only scattered portions of the block (totalling 20 ha) were planted.

Immediately after planting, staked survival plots were established by the licensee so that the impact of the infestation could be evaluated. These plots were remeasured in 1986 and the mortality level was 14% (Table 9). A portion of this mortality can be attributed to moisture stress or poor planting, because some of the dead seedlings were not defoliated.

3.2.5 Summary of site visits

These case studies show that past BAC infestations in the Clearwater Forest District have had a low impact on overall reforestation. In 13 years, the BAC has affected a total of 149 ha, which is only 6% of the total area planted in the 1986 season.

There are no obvious site parameters or events common to all four locations, with the exception of the period of time between burning and planting. All four plantations were broadcast burned during the last week of August and planted two springs later. Infestations of BAC appeared 1.5 years later, concurrent with planting, indicating that the burning took place after the adult moth flight period the previous year. Data from pheromone trapping of adult moths in the Prince Rupert Forest Region have shown that the majority of flight is completed by the 3rd week in August.[1] The implications of these biological data for explaining the degree of loss sustained during BAC infestations are discussed in the next section.

[1] Mr. Leo Unger, Canadian Forestry Service, Victoria, B.C., personal communication.

4 DISCUSSION

The potential of the BAC to affect reforestation depends on the elements of risk and hazard involved. These elements can be defined as:

risk—the chance that a pest infestation will occur in a given location.

hazard—the nature and degree of loss that will be sustained during a pest infestation in a given location.

The following factors contributing to risk and hazard of the BAC have been identified during this investigation:

A. Risk
   1. Pest population levels
   2. Environmental conditions during moth flight
   3. Proximity of populations to suitable oviposition sites
   4. Amount of broadcast burning
   5. Burning date in relation to moth flight period
   6. Planting date in relation to oviposition date

The first three risk elements either cannot be altered or such alterations have not yet been undertaken on an operational basis in British Columbia. Because of post-harvesting site conditions in the North Thompson Valley, the amount of broadcast burning (risk element 4) will remain high. Monitoring of moth flight periods and oviposition dates can reduce risk from elements 5 and 6. If slashburning occurs after moth flight and oviposition is complete for the year (events largely determined by environmental conditions), seedlings may be safely planted the following spring. Larval feeding will then not occur until the seedlings have been established for 1 year and are more tolerant of defoliation. If burning takes place before or during moth flight, the area may become infested that same year and planting should then be delayed until after larval feeding the following year. Historical records of broadcast burning dates in the study area (Table 10) indicate that over 60% occur after the end of August.

TABLE 10. Timing of broadcast burning in the Clearwater Forest District (ha)[a]

Year	June/July	August	September	October	Missing records[b]	Total
1986	666 (7.7%)[c]	3169 (36.8%)	3950 (45.9%)	818 (9.5%)	0	8603
1985	0 (0.0%)	102 (6.8%)	1272 (84.7%)	128 (8.5%)	113	1615
1984	59 (4.3%)	507 (37.3%)	416 (30.6%)	376 (27.8%)	442	1800
1983	108 (7.4%)	561 (38.3%)	741 (50.6%)	54 (3.7%)	457	1921
1982	74 (17.9%)	20 (4.8%)	282 (68.4%)	37 (8.9%)	266	679
Total	907 (6.8%)	4359 (32.7%)	6661 (49.9%)	1413 (10.6%)	1278	14 618

[a] Summarized from Silviculture Report 2D and History of Crop Establishment (FS 393) forms.
[b] Indicates records for which the month of burning was not available.
[c] Monthly totals calculated as a percentage of the total (excluding missing records).

Therefore, if the majority of moth flight is assumed to be completed by September 1, risk from factor 5 is moderate in the North Thompson Valley. This will vary considerably year to year with the timing of suitable broadcast burning conditions. In the past, planting in the study area was routinely delayed for at least 1 year after burning, in an attempt to reduce losses from BAC. The timing of planting on burned sites should, however, be more dependent on the burning date and duration of the BAC moth flight period.

B. Hazard
   1. Pest population levels
   2. Environmental conditions from the time of moth flight to the winter following defoliation
   3. Quantity and quality (species) of non-crop vegetation available during larval feeding

4. Species of seedling
5. Degree of seedling establishment
6. Population levels of natural BAC enemies

The first three hazard elements cannot be easily manipulated. Species selection (hazard element 4) depends on stock availability and site conditions. When a choice is practical, planting lodgepole pine will reduce the hazard. Hazard from element 5 can be substantially reduced if attention is paid to flight period monitoring and scheduling of planting, as discussed before. Hazard element 6 may be manipulated through biological pest-control methods, but more research on black army cutworm predators and parasites is needed.

The frequent strategy of delaying planting for 1 or more years in response to a potential or actual BAC infestation has significant consequences. The objective of reforestation is to establish at least minimum stocking to a free-growing state. Recent work in the Cariboo Forest Region has shown that the height growth of spruce seedlings in the initial 5 years after planting is reduced almost 50% when planting occurs 2 or more years after burning, probably because of competition from herbaceous and woody vegetation.[2] Because the majority of the North Thompson Valley is comprised of wet-belt forest ecosystems, vegetative competition can be severe. Therefore, a significant trade-off in productivity exists between establishing plantations as soon after burning as possible, and arbitrary planting delay to minimize damage from potential BAC infestations.

Hence, of the factors associated with the potential of BAC to cause seedling damage, foresters can control only: the amount of burning; planting dates in relation to burning, moth flight, and oviposition dates; and species selection. Based on this information, procedures for limiting BAC risk and hazard are recommended in the next section.

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[2] Mr. Alan Vyse, B.C. Forest Service, Kamloops Forest Region. Data from Experimental Project 859.06.

5 RECOMMENDATIONS

This study has determined that the BAC currently is not a major threat to reforestation in the North Thompson Valley. However, serious losses from BAC have occurred in other areas of the province, and the North Thompson situation could worsen in future. Furthermore, the costs associated with even a small number of plantation failures can be high. Implementation of the following recommendations will help foresters to monitor the risk and hazard of BAC infestations on a site-specific basis, to reduce losses and to quantify the actual losses incurred.

1. Pheromone trapping programs should be established on all broadcast burns conducted in 1987. The traps should be installed as soon as possible after burning and monitored weekly to determine the peak and duration of the flight period. These data will identify locations where the potential for a BAC infestation is minimal (high priority for immediate planting) and where infestation potential is high and planting should be delayed until after larval feeding.
2. Planting crews should be adequately trained in identifying BAC and given clear instructions to report any observations of larval feeding to the appropriate personnel immediately.
3. Whenever BAC infestations occur, accurate maps should be drawn after larval feeding to allow calculation of the area affected. Staked survival plots should then be established in both defoliated and unaffected areas of the plantation, and remeasured in the following year to determine mortality and damage levels. These maps and data should be placed in the appropriate opening number files.
4. When BAC infestations occur, attempts should be made to delay planting only until larval feeding is completed, rather than for a full year. Lodgepole pine should be the species of choice in high-risk areas.
5. Studies should be undertaken to determine if significant relationships exist between burning intensity and the selection of burns for oviposition, and among damage/mortality levels sustained by different types of planting stock and differing time frames of defoliation in relation to planting date (i.e., current with planting or 1 year following planting).

6 LITERATURE CITED

Allen, S. and C. Wood. 1973. Forest insect and disease conditions, Prince George District. Environ. Can., Can. For. Serv., Pac. For. Res. Cent., Victoria, B.C.

Blackstock, M. 1985. A means towards black army cutworm, *Actebia fennica* (Tauscher), management. B.S.F. thesis. Univ. B.C., Vancouver, B.C. 78 p.

Hodgkinson, R. 1986. A preliminary assessment of the initial impact of black army cutworm in the Prince George Forest Region. B.C. For. Serv., Int. Rep. PM-PG-5. 31 p.

Phipps, C.R. 1927. The black army cutworm, a blueberry pest. Maine Agric. Exp. Stn. Bull. 340.

Ross, D.A. and S. Illnytzky. 1977. The black army cutworm, *Actebia fennica* (Tauscher), in British Columbia. Environ. Can., Can. For. Serv., Pac. For. Cent., Victoria, B.C. 23 p.

Wood, G.W. and W.T.A. Neilson. 1956. Notes on the black army cutworm, *Actebia fennica* (Tauscher) (Lepidoptera: Phalaenidae): a pest of low-bush blueberry in New Brunswick. Can. Ent. 88:93-96.

APPENDIX 1. Map of Survey Locations